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SPECIFICATION FOR COVERED ELECTRODES FOR SURFACING OF METAL BY MANUAL METAL ARC WELDING

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Indian Standard

SPECIFICATION FOR COVERED ELECTRODES FOR SURFACING OF METAL BY MANUAL METAL ARC WELDING

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Indian Standard

SPECIFICATION FOR COVERED ELECTRODES FOR SURFACING OF METAL BY MANUAL METAL ARC WELDING

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 March 1974, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 As the loads and operation speeds increase, the rate of wear of mechanical components is accelerated. Wear may be caused by abrasion, erosion, corrosion, heat-sealing or impact, or by a combination of these factors. Unless attended to in time, such wears may lead to expensive replacement of components.

0.3 Whatever the causes of wear, facing of surfaces by welding has been accepted as a solution to the problem and can reduce maintenance costs to the minimum. Weld metal with the correct metallurgical properties for the type of service encountered can be deposited where it is most needed and only where it is needed. In many instances it may even be worthwhile economically to face new components before use, thus putting a protective layer on the part and obtain longer initial life at higher efficiency.

0.4 This standard is intended to serve as a guide for the manufacture and selection of covered electrodes for facing of metal by manual metal arc welding process, and it includes only the commonly used types of electrodes.

0.5 The choice of facing materials requires careful consideration of a number of factors, such as service conditions and metallurgical properties of the component material. A guide to the selection of facing electrodes is given in Appendix A.

0.6 In the preparation of this standard due consideration has been given to the manufacturing and trade practices followed in the field in this country. Assistance has also been derived from the following publications:

JIS Z 3251-1962 Covered electrodes for hardfacing. Japanese Standards Association.

AWS A 5.13-1969 Surfacing welding rods and electrodes. American Welding Society.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This specification prescribes the requirements for covered electrodes used for surfacing of metal by manual metal arc welding process.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 812-1957† shall apply.

3. SUPPLY OF MATERIALS

3.1 General requirements relating to the supply of surfacing electrodes shall be as laid down in IS : 1387-1967‡.

4. BASIS FOR CODING

4.1 The surfacing electrodes have been classified on the basis of the chemical composition of the deposited metal and usability characteristics.

NOTE — A guide to the classification and selection of electrodes is given in Appendix A.

4.1.1 The surfacing electrodes are classified into eight groups as Fe, FeMn, FeCr, CrNiMn, CoCr, NiCr, CuAl and CuSn based on the all-weld metal composition (*see* Table 1). In the classification code, Fe, FeMn, FeCr, CrNiMn, CoCr, NiCr, CuAl and CuSn indicating the group, is followed by an alphabet, or a digit and an alphabet to indicate the class of the electrode in the group.

4.1.2 The prefix letter ' E ' or ' D ' shall indicate the process of manufacture, that is, by extrusion or by dipping.

4.1.3 Any electrode classified under one classification shall not be classified under any other classification.

*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to welding and cutting of metals.

‡General requirements for the supply of metallurgical materials (*first revision*).

TABLE 1 CHEMICAL REQUIREMENTS FOR SURFACING ELECTRODES

(*Clause* 4.1.1)

IS Classification	Constituents, Percent																		
	Carbon	Manganese	Cobalt	Tungsten	Nickel	Chromium	Molybdenum	Iron	Vanadium	Copper	Aluminium	Zinc	Silicon	Lead	Tin	Sulphur	Phosphorus	Boron	Total of Other Elements
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
E Fe-A	0·20	3·0	—	—	—	3·0	1·5	Remainder	—	—	—	—	1·0	—	—	0·03	0·03	—	1·0
E Fe-B	0·20	3·0	—	—	—	5·0	1·5	Remainder	—	—	—	—	1·5	—	—	0·03	0·03	—	1·0
E Fe-1C	0·30-0·60	0·60-1·00	—	—	—	5·0-9·0	0·50	Remainder	0·50	—	—	—	0·50	—	—	0·03	0·03	—	1·0
E Fe-2C	0·50-0·90	0·5	—	1·0-2·5	—	3·0-5·0	5·0-9·5	Remainder	0·80-1·30	—	—	—	0·7	—	—	0·03	0·03	—	1·0
E Fe-3C	0·60-1·00	3·0	—	—	—	5·0	1·5	Remainder	—	—	—	—	1·0	—	—	0·03	0·03	—	1·0
E Fe-4C	0·30-0·60	3·0	—	—	—	3·0-9·0	1·5	Remainder	—	—	—	—	1·5	—	—	0·03	0·03	—	1·0
E Fe-5C	0·60-1·50	3·0	—	—	—	3·0-9·0	2·0	Remainder	—	—	—	—	1·5	—	—	0·03	0·03	—	1·0
E Fe-6C	0·30-0·70	4·0	—	—	—	9·0-14·0	2·0	Remainder	—	—	—	—	1·5	—	—	0·03	0·03	—	2·5
E FeMn-A	1·00	12-16	—	—	—	—	—	Remainder	—	—	—	—	0·8	—	—	0·03	0·03	—	1·0
E FeMn-B	1·00	12-16	—	—	2·75, *Min*	0·50	—	Remainder	—	—	—	—	0·3-1·3	—	—	0·03	0·03	—	1·0
E FeMn-C	1·00	12-16	—	—	—	0·50	0·6-1·4	Remainder	—	—	—	—	0·3-1·3	—	—	0·03	0·03	—	1·0
E FeCr-A	0·15	2·0-3·50	—	—	2·0-4·0	16-19	—	Remainder	—	—	—	—	0·5	—	—	0·03	0·03	—	1·0
E FeCr-B	3·0-5·0	4·0-8·0	—	—	—	26-32	—	Remainder	—	—	—	—	1·0-2·5	—	—	0·03	0·03	—	1·0
E FeCr-C	3·0-5·0	1·0	—	—	2·5-4·5	26-32	—	Remainder	—	—	—	—	0·5-2·0	—	—	0·03	0·03	—	1·0
E CrNiMn-A	0·15	2·0-4·0	—	—	4·0-6·0	17-19	—	Remainder	—	—	—	—	0·50	—	—	0·03	0·03	—	1·0
E CrNiMn-B	0·15	4·0-6·0	—	—	8·0-11·0	18-20	—	Remainder	—	—	—	—	0·50	—	—	0·03	0·03	—	1·0
E CoCr-A	0·7-1·4	2·0	Remainder	3·0-6·0	3·0	25·0-32·0	1·0	5·0	—	—	—	—	0·4-2·0	—	—	—	—	—	0·50
E CoCr-B	1·0-1·70	2·0	Remainder	7·0-9·5	3·0	25·0-32·0	1·0	5·0	—	—	—	—	0·4-2·0	—	—	—	—	—	0·50
E CoCr-C	1·75-3·0	2·0	Remainder	11-14	3·0	25·0-33·0	1·0	5·0	—	—	—	—	0·4-2·0	—	—	—	—	—	0·50
E NiCr-A	0·30-0·60	—	1·50	—	75·0-85·0	8·0-14·0	—	1·25-3·25	—	—	—	—	1·25-3·25	—	—	—	—	2·0-3·0	0·50
E NiCr-B	0·40-0·80	—	1·25	—	71·0-81·0	10·0-16·0	—	3·0-5·0	—	—	—	—	3·00-5·00	—	—	—	—	2·0-4·0	0·50
E NiCr-C	0·50-1·00	—	1·00	—	65·00-75·00	12·0-18·0	—	5·50	—	—	—	—	3·50-5·50	—	—	—	—	2·5-4·0	0·50
E CuAl-A	—	—	—	—	—	—	—	3·0-5·0	—	Remainder	12·0-13·0	0·02	0·04	0·02	—	—	—	—	0·50
E CuAl-B	—	—	—	—	—	—	—	3·0-5·0	—	Remainder	13·0-14·0	0·02	0·04	0·02	—	—	—	—	0·50
E CuAl-C	—	—	—	—	—	—	—	3·0-5·0	—	Remainder	14·0-15·0	0·02	0·04	0·02	—	—	—	—	0·50
E CuSn-A	—	*	—	—	*	—	—	—	—	Remainder	0·01*	*	*	0·02*	4·8-5·8	0·03	0·15-0·35	—	0·50

NOTE 1 — Analyses given are of the deposited weld metal.

NOTE 2 — Analysis shall be made for the elements for which specified values are shown in this table. If, however, the presence of other elements is indicated in a course of routine analysis, further analysis shall be made to establish that the total of the other elements present is not in excess of the limits specified for 'Total of Other Elements' in the last column in the table.

NOTE 3 — Single values shown are the maximum percentage, except where otherwise specified.

*Total of the percentage of other elements including the elements marked with asterisk (*) shall not exceed the value specified.

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4.1.4 The usability characteristics shall be indicated by a three-digit suffix following the primary designation. The first digit indicates the type of covering, the second the position of welding and the third, the current conditions as follows:

First Digit	*Types of Covering*
3	Containing an appreciable amount of titania and producing a fluid slag
6	Having a high content of calcium carbonate and calcium fluoride
9	A covering of any other specification not classified above

Second Digit	*Position of Welding*
1	F, H, V, O
3	F
9	Any other position of welding not specified above

Third Digit	*Current Condition*
0	D +
1	D +, A 90
2	D −, A 70
4	D +, A 70
6	D ±, A 70
9	Any other current condition not classified above

5. SIZES

5.1 The size of the electrode shall be designated by the diameter of the core wire in millimetres. The designation and the size of the electrodes shall be as given below:

Designation of the Electrode Size	*Diameter of the Core Wire*
	mm
2	2·00
2·5	2·50
3·15	3·15
4	4·00
5	5·00
6·3	6·30
8	8·00

5.2 Tolerance on Size — The tolerance on the specified diameter of the core wire shall be as follows:

Size of Wire mm	*Tolerance*, mm	
	Drawn Core Wire	Cast Core Wire
Up to and including 3·15	± 0·05	± 0·06
4 and up to and including 8·00	+ 0·05 − 0·10	± 0·10

5.3 Length — The length of various sizes of electrodes shall be as given below:

Size Designation mm	*Length* mm
2	200, 250, 300, 350
2·5	250, 300, 350
Above 2·5	350, 450

5.4 Tolerance on Length — The tolerance on length of individual electrode sizes over nominal length shall be ±6 mm.

6. GENERAL REQUIREMENTS

6.1 The contact end of the electrode shall be bare and clean over a length 20 to 30 mm.

6.1.1 The arc-striking end of the electrode shall permit easy striking of the arc. When the end is bare the distance from the arc end to the first point where full cross-section of the covering prevails shall not exceed the diameter of the core wire, subject to a maximum of 2·5 mm.

6.2 Covering — The flux covering shall comply with the requirements given in **6.2.1**, **6.2.2**, **6.2.3** and **6.2.4**.

6.2.1 *Strength* — The covering shall be sufficiently robust to withstand without damage normal conditions of handling, storage and use.

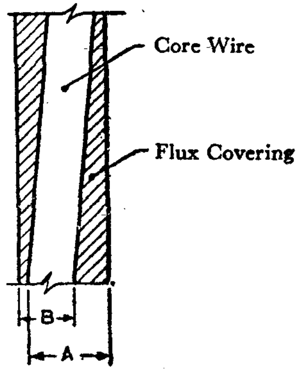
6.2.2 *Uniformity* — The covering shall be uniform in outside diameter and in thickness. The tolerance permitted for uniformity of covering shall be such that the maximum core plus one covering dimension (*see* Fig. 1) shall not exceed the minimum plus one covering dimension by more than:

a) 5 percent of the mean of the two dimensions in the case of electrodes with cast core wires, and

b) 3 percent of the mean of the two dimensions in the case of electrodes with drawn core wire.

6.2.3 The covering shall fuse or burn or both evenly and shall be such that heating of the electrode during welding shall not cause injurious blistering or flaking of the covering within the range of current recommended by the manufacturer.

6.2.4 Core wire and covering shall be free from defects which would interfere with uniform performance of the electrode.



$$A - B \not> \frac{3}{100}\left(\frac{A+B}{2}\right) \text{ for drawn core wire}$$

$$A - B \not> \frac{5}{100}\left(\frac{A+B}{2}\right) \text{ for cast core wire}$$

where

A = core-plus-one maximum covering dimension, and

B = core-plus-one minimum covering dimension.

FIG. 1 PERMISSIBLE TOLERANCE FOR FLUX COVERING

7. TEST REQUIREMENTS

7.1 For assessing the performance of the electrodes, they shall be subjected to the following tests:

a) Chemical analysis,
b) Usability test, and
c) Production control test.

7.2 Parent Metal for Test Plates — The parent metal for conducting the tests specified in **7.1** shall be mild steel conforming to IS : 2062-1969* or the equivalent.

7.3 Chemical Analysis — The test sample of weld metal obtained using electrodes of size 3·15 and the largest in the range of manufacture, as given in the procedure specified in Appendix B, when analysed in accordance with the accepted trade and technological practices subject to agreement between the purchaser and the manufacturer, shall have the chemical composition given in Table 1.

7.4 Usability Test — This test on the deposited weld metal shall be made using electrodes of 3·15 mm core wire dia and the largest in the range of manufacture in accordance with the method described in Appendix C.

7.5 Production Control — The manufacturer shall satisfy himself by means of a suitable system of control, that the composition and quality of all the electrodes currently produced are similar to those subjected to the tests specified in **7.3** and **7.4**. He shall ensure that the results of production control tests and the date of manufacture is traceable from the batch number or other relevant details.

NOTE — A batch is defined as being of the same dry mix, the same cast number and the same size of wire.

7.5.1 The manufacturer on request shall make available to the approving and certifying authorities the records maintained for production control to ensure that the composition and quality of all the electrodes currently produced are similar to those subjected to the tests in **7.3** and **7.4**.

8. RETESTS

8.1 Where any test specimen fails to satisfy the test requirements, two further test specimens shall be prepared (using electrodes from the same batch) and submitted for the tests in which the requirements were not

*Specification for structural steel (fusion welding quality) (*first revision*).

fulfilled. The electrodes shall be deemed as not complying with this standard unless the test on both the additional specimens are satisfactory.

9. PACKING AND STORAGE

9.1 The net weight of an individual bundle or carton of electrodes shall not exceed 7 kg.

9.1.1 Electrodes shall be suitably packed to guard against damage during transportation. The packing shall be suitable to ensure that under normal store room conditions, the electrodes shall be capable of giving the results in accordance with the provisions of this specification for at least 6 months after despatch from the manufacturer's stores. If the flux covering is of a type requiring special protection during storage, the details of such special protection shall be furnished by the manufacturer, and a reference to this should be included in the marking of the bundle or box of electrodes. The electrodes shall be stored in dry atmosphere.

9.1.2 Each bundle or package shall contain the manufacturer's certificate guaranteeing that the electrodes therein comply with the chemical analysis and performance requirements set forth in this standard.

9.1.3 If the marking on the bundle includes the ISI Certification Mark (*see* **11.1.2**), the manufacturer's certificate need not be included.

10. TEST RESULTS

10.1 On request, as evidence that the electrodes supplied comply with the requirements of this specification, the manufacturer shall produce the results of the most recent tests carried out within the preceding 12 months on the electrodes representative of the electrodes supplied.

10.2 If required, the manufacturer shall make available to the customer the manufacturer's test certificate giving the chemical analysis of weld deposit for each batch of electrodes.

11. MARKING

11.1 Each bundle or package of electrodes shall be clearly marked with the following information (*see also* **9.1.1**, **9.1.2** and **9.1.3**):

a) Code designation;

b) Name of the manufacturer;

c) Trade designation of electrodes;

d) Size;

e) Batch number (*see* **7.5**);

f) Recommended current range; and

g) Recommendations for special storage condition, if necessary (*see* **9.1.1**).

11.1.1 Colour coding of metal arc welding electrodes shall conform to IS : 5462-1969*.

11.1.2 The bundle or package of electrodes may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

APPENDIX A

(*Clauses* 0.5 *and* 4.1)

GUIDE FOR CLASSIFICATION AND SELECTION OF ELECTRODES

A-0. GENERAL

A-0.1 This Appendix has been included merely as a guide to the classification and selection of electrodes and it does not form a part of the specification. It has been prepared as an aid to prospective users of the welding electrodes covered by this specification in determining which classification of electrode is best suited for a particular application.

A-0.2 The specification itself is intended to provide both the manufacturer and the purchaser with a means of production control and a basis of acceptance through mutually acceptable sound standard requirements.

A-1. IS CLASSIFICATION E Fe-A

A-1.1 The E Fe-A electrodes have proved very popular for applications on mild steel, carbon steel and low-alloy steels where approximately 250 HB hardness is required. Some typical surfacing applications are those in

*Colour code for identification of covered electrodes for metal arc welding.

gears, pinion teeth, railway and tramcar rails and machine parts where moderate hardness and toughness combined with easy machinability are required.

A-2. IS CLASSIFICATION E Fe-B

A-2.1 The E Fe-B electrodes are suitable for application on mild steel, carbon steel, cast steel and low-alloy steels. The air hardening type weld deposit which is machinable has a hardness between 350-380 *HB**. Some of the applications include those in shear blades, hot punching dies, rail ends, brake shoes, cog wheels, plough shares, wobblers, etc, where resistance to abrasion combined with toughness is required.

A-3. IS CLASSIFICATION E Fe-C

A-3.1 The E Fe-C electrode deposit is essentially high speed steel, modified slightly for welding applications. These electrodes are more suitable for use on cutting tools, hot working tools and for applications requiring toughness. The deposited weld metal has a hardness between 450 and 700 *HB** depending on the parent metal those in and the number of layers welded. Some typical surfacing applications are those in cutting tools, shear blades, reamers, forming dies, shearing dies, ingot tongs and similar tools.

A-3.1.1 The E Fe group of electrodes in grades A, B and C provides a weld deposit which can withstand medium impact without cracking. After tempering, the impact resistance is increased appreciably.

A-3.1.2 The weld metals can withstand atmospheric corrosion but it is not effective in providing resistance to liquid corrosion.

A-3.1.3 The high-stress abrasion resistance of the weld metal, as deposited, at room temperature, is much better than that of low carbon steel but they are not considered high abrasion resistant alloys. Resistance to deformation at elevated temperatures up to 600°C is their outstanding feature and this may aid hot abrasion resistance.

A-3.1.4 Weld deposits are well suited for metal-to-metal wear, especially at elevated temperatures. The compressive strength is very good and will fall or rise with the tempering temperature.

A-4. IS CLASSIFICATION E FeMn AUSTENITIC MANGANESE STEEL ELECTRODES

A-4.1 The E FeMn-A and E FeMn-B electrodes are substantially equivalent except that the yield strength of E FeMn-B weld deposit is higher than that of E FeMn-A. For track work the higher yield is considered an asset.

**See* IS : 1500-1968 'Method for Brinell hardness test for steel (*first revision*)'.

A-4.1.1 The most appropriate surfacing applications with E FeMn electrodes are in places where metal-to-metal wear and impact occur. Some typical surfacing applications are in rock crushers, railway frogs and crossings, shovels, coal crushers, cement grinder rings.

A-4.1.2 *Hardness* — The normal hardness of these weld deposit is 170 to 230 *HB*, but this is misleading since they work harden very readily to 450 to 550 *HB*.

A-4.1.3 *Hot Hardness* — Reheating above 260 to 315°C may cause serious embrittlement. Therefore, hot hardness is not a property worth taking into account.

A-4.1.4 *Impact* — The E FeMn electrodes, as deposited, are usually considered outstanding material for heavy impact services.

A-4.1.5 *Oxidation and Corrosion Resistance* — The weld metal is not oxidation and corrosion resistant; it is similar to ordidary carbon steel in this respect.

A-4.1.6 Abrasion resistance to high and low stress abrasion is moderate as against that of hard abrasives like quartz.

A-5. IS CLASSIFICATION E FeCr

A-5.1 The E FeCr-A electrodes are suitable for surfacing applications on mild steels, carbon steels, low-alloy steels and austenitic manganese steels where resistance to the combined effects of abrasion, impact and corrosion is necessary. The weld, as deposited, has a Brinell hardness of about 250 *HB*, which rapidly rises to 500 *HB* under impact in service.

A-5.1.1 Some typical applications are those in shovel tracks, coal mining cutters, dipper teeth, rock crushers, tractor grousers, mill hammers, sand and pump impellers, valve seats, etc.

A-5.1.2 The E FeCr-B and E FeCr-C electrodes are basically similar, the main difference being in the appearance of the final deposit.

A-5.1.3 *Hardness* — The as-welded hardness of the weld deposit will vary with carbon content. The average Brinell hardness of the weld metal is in the range 500-700 *HB*.

A-5.1.4 *Hot Hardness* — Hardness falls slowly with temperatures up to about 425 to 482°C and thereafter falls rapidly.

A-5.1.5 *Oxidation Resistance* — The high chromium content of the weld metal confers excellent oxidation resistance up to 980°C and they can be considered for hot wear applications where hot plasticity is not applicable

A-5.1.6 *Corrosion Resistance* — The matrix chromium content of the weld metals are comparatively low and, therefore, they are not very effective in providing resistance to liquid corrosion.

A-5.1.7 *Abrasion* — Resistance to low-stress scratching abrasion is outstanding and it is related to the volume of the hard carbides.

A-5.1.8 *Applications* — Industrial applications include those in coke chutes, steel mill grinders, blast furnace bells, sand blasting equipment and brick machinery.

A-6. IS CLASSIFICATION E CrNiMn

A-6.1 The E CrNiMn electrodes have become very popular in the reclamation of worn out parts both for buffer layers and for surfacing applications on mild steel, carbon steel, low alloy steel and stainless steel, where resistance to the combined effect of impact and corrosion is necessary.

A-6.1.1 *Hardness* — The hardness of the weld metal, as deposited, is about 200 *HB*, which rapidly rises to 500-550 *HB* under impact in service.

A-6.1.2 *Applications* — Some typical applications are: laying buffer layer on austenitic manganese steels before surfacing, putting cushion layers in between runs where heavy building is required, and those in crusher cones, crusher jaws, clam shell bucket lips, conveyors, dipper teeth, pulverizer ploughs, rail points and crossings and shovel lips.

A-7. IS CLASSIFICATION E CoCr

A-7.1 The E CoCr-A electrodes are used on contact surfaces of exhaust valves in aircraft, truck, bus and diesel engines, which are frequently surfaced with softer alloys of the E CoCr-A type of electrode. Its success is attributed to its combination of resistance to heat, corrosion and oxidation. It is also used on valve seats in steam engines, pump shafts and similar parts which are subjected to corrosion and erosion.

A-7.1.1 The higher carbon filler metals, E CoCr-B and E CoCr-C are used in those applications where greater hardness and abrasion are needed, but where impact resistance is not mandatory.

A-7.1.2 *Hardness* — The average hardness *HB* by layers for E CoCr-A, E CoCr-B and E CoCr-C electrodes are given in Table 2.

TABLE 2 WELD DEPOSIT HARDNESS BY LAYERS

(*Clause* A-7.1.2)

Room Temperature Hardness Data of E CoCr Electrode Deposits

Type	Average Hardness by Layers, Brinell		
	1	2	3
E CoCr-A	240	300	370
E CoCr-B	320	360	440
E CoCr-C	360	450	550

Note 1 — Lower values can be expected in single layer deposits due to dilution with softer metal.

Note 2 — Hardness may vary among base metals depending on the proportion of hardening elements present in the parent metal.

A-7.1.3 *Hot Hardness* — Elevated temperature strength and hardness are outstanding properties of this group. They are generally considered superior to other surfacing alloys where these properties are required above 650°C.

A-7.1.4 Impact-resistance to flow under impact increases with carbon content in this group. E CoCr-C weld deposits are quite brittle and crack readily when impact flow does occur. E CoCr-A deposits, while they deform more easily, can withstand some plastic flow under compression before cracking.

A-7.1.5 *Corrosion Resistance* — E CoCr weld metals are recognized as ' Stainless ' and are frequently useful where both abrasion and corrosion are involved. However, if an application that involves corrosion is under consideration, a field test should be conducted to check on corrosion resistivity.

A-7.1.6 *Abrasion* — Abrasion properties of E CoCr type are considered good. But the abrasion resistance depend on the carbon content.

A-7.1.7 *Metal-to-Metal Wear* — E CoCr weld metals are well suited for metal-to-metal wear.

A-8. IS CLASSIFICATION E NiCr

A-8.1 For the E NiCr electrodes, chemical composition as specified in Table 1 does not determine the physical properties as clearly as it does for

the other filler metals in this specification. Hardness of deposit increases from E NiCr-A to E NiCr-C, but machinability and toughness decreases. Selection is generally based on these factors.

A-8.1.1 Deposits of the E NiCr electrodes have good metal-to-metal wear resistance, good low stress scratch resistance, corrosion resistance and retention of hardness at elevated temperature.

A-8.1.2 *Application* — The E NiCr electrodes are suitable for use on seal rings, cement pump screws, valves, screw conveyors, cams, etc.

A-8.1.3 *Hardness* — The hardness (*HB*) of the weld deposits (as welded) and the hardness of weld deposit (under various service temperatures) is shown in Table 3.

TABLE 3 WELD DEPOSIT HARDNESS

IS Classification	As-welded Hardness		Average Hot Hardness at Various Service Temperatures		
	Number of Layers	Hardness *HB*	300°C *HB*	425°C *HB*	550°C *HB*
(1)	(2)	(3)	(4)	(5)	(6)
E NiCr-A	1	248-277	285	277	229
	2	285-331			
E NiCr-B	1	285-331	388	363	277
	2	375-429			
E NiCr-C	1	331-429	477	429	321
	2	477-578			

A-8.1.4 Deposits of E NiCr electrode will withstand light impact fairly well. However, if the impact blows produce plastic deformation, cracks are certain to appear in the E NiCr-C weld metal and less likely to appear in the E NiCr-A and E NiCr-B deposits.

A-8.1.5 *Oxidation Resistance* — E NiCr deposits are oxidation resistant up to 980°C because of their high nickel and chromium content. However, incipient fusion may occur near this temperature and the use of these filler metal above 950°C is not recommended.

A-8.1.6 *Corrosion Resistance* — E NiCr deposits are completely resistant to atmospheric steam and salt water corrosion. They are also resistant to mild acids and many common corrosive chemicals. However, on applications involving corrosion a field check should be conducted to check on corrosion resistivity.

A-8.1.7 *Abrasion* — The high carbon classification, E NiCr-C of this group has excellent resistance to low-stress scratching abrasion and it is particularly valuable where such abrasion and corrosion is combined. Abrasion resistance is expected to decrease with carbon content. These filler metals are not recommended for high-stress grinding abrasion.

A-8.1.8 *Metal-to-Metal Wear* — E NiCr deposits have excellent metal-to-metal wear resistance and take high polish under wearing conditions. These properties are shown best by E NiCr-C alloy.

A-9. IS CLASSIFICATIONS E CuAl AND E CuSn

A-9.1 The copper-base alloy electrodes covered by this specification are used to deposit overlays and inlays for bearing, corrosion-resistant and wear-resistant surfaces.

A-9.2 The E CuAl-A electrodes are used primarily for the surfacing of bearing surfaces requiring higher hardness in the ranges 140 to 290 *HB*.

A-9.3 Classification E CuAl-B and E CuAl-C are used to surface bearing and wear resisting surfaces requiring higher hardness of 230 to 390 *HB*, such as those of gears, cams, sheaves, wear plates, dies, etc.

A-9.4 The copper-tin (E CuSn) electrode is used primarily to surface bearing surfaces where the lower hardness of these alloys is required, such as for surfacing corrosion-resistant surfaces, and occasionally for wear-resistant applications.

A-9.5 Many of these electrodes can also be used for joining like and dissimilar metal, as well as for repair of castings.

A-9.6 Hardness — Hardness of the deposit will vary with the welding process and the manner in which the metal is deposited. Deposits made with metal arc process will have low hardness values because of high losses of aluminium tin, silicon and zinc during the remelting process. Hardness range of these alloys is given in Table 4.

TABLE 4 HARDNESS VALUES OF COPPER BASE ALLOYS

IS Classification	Brinell Hardness of Deposit, *HB*	
	3 000-kg Load	500-kg Load
E CuAl-A	180 to 220	—
E CuAl-B	230 to 270	—
E CuAl-C	280 to 320	—
E CuSn-A	—	70 to 85

A-9.6.1 *Hot Hardness* — The copper base alloys are not recommended for use at elevated temperatures since the mechanical properties and especially hardness will tend to decrease consistently as the temperature increases above 204°C.

A-9.7 Impact — The CuAl deposits will have high impact resistance. The CuSn electrode as deposited has low impact value due to coarse grain structure and the lower strength inherent in these alloys.

A-9.8 Oxidation Resistance — Deposits of CuAl electrodes form a protective oxide coating upon exposure to the atmosphere. Oxidation resistance of CuSn deposit would be comparable to that of pure copper.

A-9.9 Corrosion-Resistance — These copper base alloy electrodes are used rather extensively to surface areas subjected to corrosion from many acids, mild alkalies and salt water, the only exception being E CuSn-A classification. The electrodes producing deposits of higher hardness, that is, 120 to 200 *HB* (3 000-kg load), may be used to surface areas subjected to corrosive actions as well as erosion from liquid flow as in condenser heads and turbine runners.

A-9.10 Abrasion — None of the copper-base alloy deposits is recommended for use where severe abrasion is encountered in service.

A-9.11 Metal-to-Metal Wear

A-9.11.1 The CuAl electrodes producing deposits from 130 to approximately 390 *HB* (3 000-kg load) are used to overlay surfaces subjected to excessive wear from metal-to-metal contact, such as in gears, cams, sheaves, wear plates and dies. For example, CuAl-C electrodes are used to surface dies, both male and female, for drawing and forming stainless and mild steels.

A-9.11.2 All the copper base alloy electrodes covered by this specification are used to deposit overlays and inlays on bearing surfaces. Copper-base alloy filler metals should be selected for a bearing surface producing a deposit 50 to 75 *HB* lower than that of the mating metal or alloy so that the bearing surface will wear in preference to the mating part. Slight porosity in the deposit is generally acceptable for bearing service.

APPENDIX B

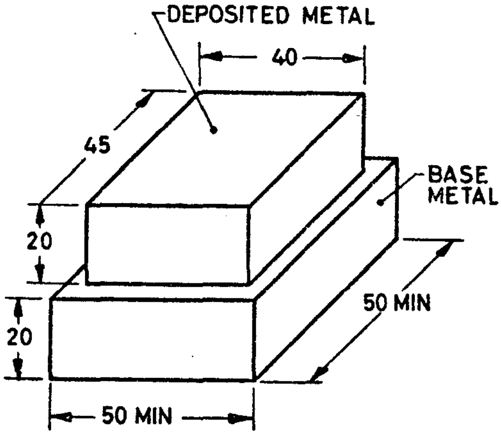
(*Clause* 7.3)

CHEMICAL ANALYSIS OF WELD METAL

B-1. The test pad shall be made up as shown in Fig. 2 using the electrode in flat position and following the welding procedure specified by the manufacturer as to factors not covered herein. The full length of each covered electrode shall be used, with the stub length not exceeding 40 mm.

B-1.1 The top surface of the pad shall be removed and discarded and a minimum sample of 50 g shall then be removed from the test pad by an appropriate means. Post-heat treatment may be used to soften the test pad and to facilitate easy removal of sample. Metals for the sample shall not be removed closer than 5 mm from the base metal. No oil or other lubricant shall be used while removing the sample.

B-1.2 Chemical analysis may be made by any suitable method agreed to between the manufacturer and the purchaser.



All dimensions in millimetres.

FIG. 2 TEST PIECE FOR CHEMICAL ANALYSIS AND USABILITY TEST

APPENDIX C

(*Clause* 7.4)

USABILITY TESTS

C-1. PREPARATION OF TEST PIECE

C-1.1 The parent metal for test pieces shall be as specified in Appendix A. The temperature of the parent metal used for making the test pieces shall be 27 ± 2°C immediately before depositing the first run of weld metal.

C-1.2 A test pad shall be prepared as shown in Fig. 2, using the techniques, position and other factors specified by the manufacturer.

C-1.3 While welding the pad, the performance of the electrodes can also be checked for smooth and even weld deposit; no excessive spatter loss, and constant arc stability when used within the current ranges recommended by the manufacturer. Slag should be readily removable with hand tool.

C-1.4 The surface of the pad shall be ground smooth and clean, after which the surface shall be examined visually. The surface shall be free from injurious defects.

C-1.5 Necessary tests may also be conducted for guidance, in a manner agreed to between the manufacturer and the user to check the hardness of the weld deposit with reference to the details, given in Appendix A. Since hardness value depends on many factors, if the hardness result is found above or below the limit specified in Appendix A, the electrode shall not be considered to have failed in the test.

(*Continued from page* 2)

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